

CARRYING CAPACITY OF SINGALILA NATIONAL PARK

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ABSTRACT

Carrying capacity is important to measure the maximum number of permissible visitors and usability of a land or a park or some eco-sensitive zones. Allowable environmental changes without compromising the bio-diversities of such land zones give rise to this concept. Its calculation is very useful in tourism planning. Determination of carrying capacity of Singalila National Park is being presented here using five main limiting factors - visitors' inflow, vehicles' entry, the vastness of the area, space ideally to be available to each visitor and specific visiting time in a year-round.

KEY WORDS: Carrying Capacity & Singalila National Park

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INTRODUCTION

Singalila National Park holds world-wide popularity to tourists and trekkers. It now attracts nearly 26000 visitors annually. One of the most threats to the forest park is that the natural resources could be degraded by extreme visits. There should be a restriction on the number of visitors so that regeneration capabilities of the park don't hamper. Herein lies the importance of the Carrying Capacity concept. The concept, though suggested first in the 1930s for park management [10], its proper application started post 1960. At first, mainly guided by the population growth theory (which is the restriction on maximum population growth of an individual species without hampering ecosystem balance), it handles ecological issues which impact on forest's regenerating power. Lee et al. [4], Munar [11] discussed the Carrying Capacity that depicts the maximum limit crossing which damages to the natural resources can be irrecoverable. They presented a mathematical formula to assess how many visitors are enough for sustainable tourism. Mexa and Coccossis [12] discussed that how Carrying Capacity evaluation can be used as an effective tool for park management. Many papers are available in literature evaluating the Carrying Capacity based on physical, ecological, psychological and economical approaches [13,14,15]. Later, social impacts were also included in Carrying Capacity [6]. Thus, Carrying Capacity has two pillars: environmental capacity and social capacity [5,16]. This paper aims at calculating carrying capacity as a method for forest management for Singalila National Park, using the framework given by Cifuentes [17]. This framework gives the maximum number of visits in the park that is just enough to keep the balance among the environmental resources without an unacceptable change in the physical condition. Therefore, this paper approaches to find out optimum allowable number of visits within the reversible potentiality of the park based on physical Carrying Capacity.

Approaches to Estimate the Carrying Capacity

Limits of acceptable change (LAC) determine carrying capacity of a protected area and its estimation is based upon local and governmental policies, effectiveness of the planning and long-term goals and continuous

development of the area [18]. Some termed carrying capacity as an abstract idea and seldom gives a view of the actual scenario in a particular zone [19, 20]. Various definitions and approaches of the carrying capacity, being existed, a model and its prerequisites were framed in 1985 to determine LAC and to estimate the Carrying Capacity in Tourism Development without hampering the environmental planning and development [21].

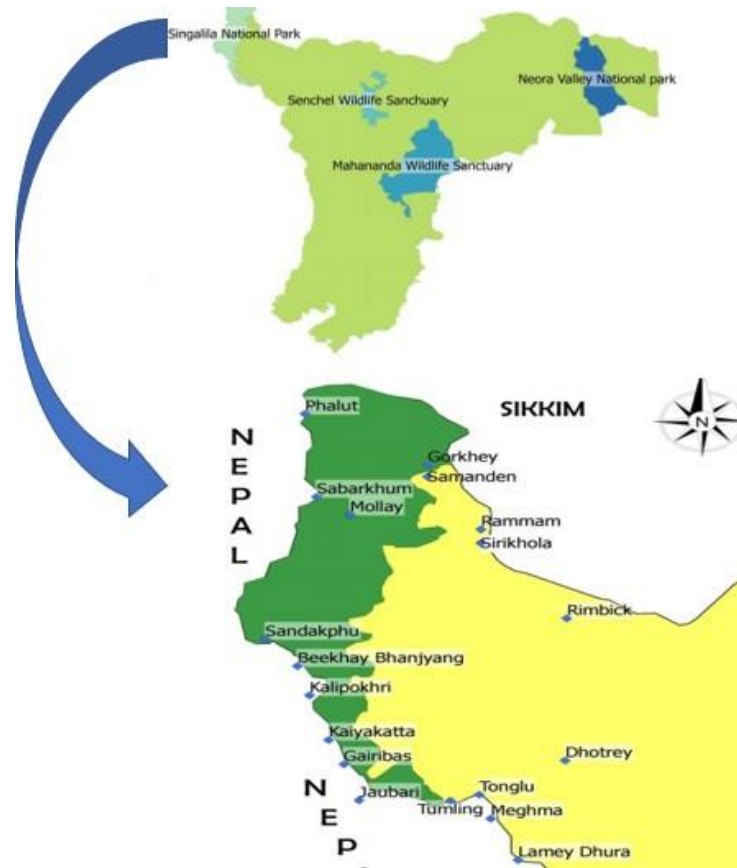


Figure 1: Singalila National Park.

From the management point of view, LAC can be termed as a linkage between the theory and reality within the limits of restriction imposed by environmental constraints and prerequisite objectives. Various methods are developed to estimate physical, real and effective carrying capacities. Some of these methods incorporate weighted valuation of different parameters and their multi-criteria ranking, simple and compound ecological and footprint models, etc. [8,22]. One of these approaches to determine the carrying capacity of protected regions with tourism allowed inside it is the framework proposed by IUCN in 1996 [21].

Physical Carrying Capacity[21]

Pcc can be defined as the maximum number of visitors who may come or gather to a place at a time. This number for tourist regions can be derived using the below formula:

$$Pcc = A \times \frac{v}{a} \times Rf \quad (1)$$

A = the forest/protected zone area;

$\frac{v}{a}$ = the space that a visitor requires to move freely without any interference from external factors (under normal

conditions, this amount is about 4 square meters per individual and may vary with natural limitations and sensitivity of the zone); and

R_f = the daily number of visits to a place

$$\frac{\text{period of location availability}}{\text{average visit time}} \quad (2)$$

Real Carrying Capacity [21]

Rcc is the maximum permitted number of visitors to a protected zone without hampering the sensitivity of the area. The limiting factors may come 3 from various parameters under biophysical, ecological, social and managerial spheres. Rcc can be derived with the below equation:

$$R_{cc} = P_{cc} \times \frac{100 - Cf_1}{100} \times \frac{100 - Cf_2}{100} \times \dots \times \frac{100 - Cf_x}{100} \quad (3)$$

$$Cf_+ = \frac{M_1}{M_+} \times 100 \quad (4)$$

where Cf_+ = the constraint (limiting) factor of a parameter expressed in percent,

M_1 = the limiting value of the parameter, whereas its total value = M_+ .

Here we present a formula to calculate the impact of increase in pollution-making elements. Let the initial count such an element in the base year is y_1 and increase in number at the end of that year is δ_1 . Then, initial count for the next year will be $y_1 + \delta_1$ and the increase in number at the end of that year is δ_2 , say. So is for the coming year and so on. We propose the below formula to calculate the Cf due to any element which can act as a source of pollution during n years.

$$Cf_- = \frac{1}{n-1} \left[\sum_{i=2}^n \frac{\delta_i}{y_{i-1}} \right] \times 100 \quad (5)$$

Where y_i is the number of the elements at the end of i th year, δ_i is the number the elements increased from (i - 1) th to i th year, i.e., $[y_i - y_{i-1}]$ and $\delta_1 = 0$.

Effective Carrying Capacity [21,23]

Ecc is the maximum number of visitors to an area/zone that can be managed in a sustainable way within the limit set by its management capacities (MC). Various variables/parameters such as governmental rules and policies, infrastructure, equipment, management resources and financial strength determine the management capacities (MC).

$$MC = \frac{(\text{Infrastructure} + \text{Equipment} + \text{Personnel}) \times 100}{3} \quad (6)$$

$$Ecc = Rcc \times MC \quad (7)$$

Without proper management capacities, it is a problem to administer the park area and hence it is a threat to the biodiversity of the park. The following relation holds among Pcc, Rcc, Ecc: $Pcc > Rcc > Ecc$ [23].

Steps to Calculate the Carrying Capacities

- Calculate the physical carrying capacity (Pcc) using the equation (1).
- Calculate the Cf_+ and Cf_- using the equations (4) and (5).

- Trekking route between Meghma, Tumling and Dhotrey = $2 + 2 + 6 = 10$ km.
- Trekking route between Srikhola and Sandakphu = $6 + 10 = 16$ km.
- Trekking route around Phalut centering Molley = $15 + 9 = 23$ km.
- Let us assume that the width of two land rovers is the total width of the motorable road. With this assumption, total width of these motorable road would be roughly $1.75 \times 2 = 3.5$ m.
- Let the width of the trekking only route is roughly 1 m. Total explorable area on foot or by road would be: $(53+50) \times 10^3 \times 3.5 + (10+16+23) \times 10^3 \times 1 = (360.5 + 49) \times 10^3 = 4, 09, 500$ sq.m.
- Consider another 4 meter (on an average) explorable area beside the motorable and trekking roads. Such area sums upto $(53 + 50 + 10 + 16 + 23) \times 10^3 \times 4 = 6, 08, 000$ sq.m.

Hotels at the Park

Location Lodge/Homestay		Nepal/India	Area of the homestay	Local Landrover Distance from Manebblains	
Chitrey	Hawk's Nest Homestay(Nepal)	Nepal	0.20 Ha	No	NA
	Izifiso Backpacker's Camp(Nepal)	Nepal	0.25 Ha		
amaydhur	Tea stalls	Nepal	0.1 Ha	2	10.5 km
Tonglu	Trekker's Hut, GTA	India	0.25 Ha	9	12.4 km
	DM'S Banglow	India	0.22 Ha		
	Private lodge	India	0.2 Ha		
Tumling	Arjun, Pasang homestay and Dawa homestay	nepal	0.6 Ha	No	NA
	Shikhar Lodge		0.25 Ha		
	Red Panda Homestay		0.25 Ha		
	Mountain Lodge		0.25 Ha		
	Siddharth Lodge		0.25 Ha		
Gairibas	Trekker's Hut, GTA	India	0.25 Ha	2	21 km
	Magnolia Lodge, Solu homestay	Nepal	0.3 Ha		
Kayekata	habre Nest	Nepal	0.2 Ha		24 km
Jaubari	Indira Lodge, Mountain	nepal	1 Ha	1	
Kalipokhari	Kanchanjongha	Nepal	0.43 Ha	9	30 km
	Dawa		0.3 Ha		
	Singalila		0.51 Ha		
	Pandim Lodge		0.51 Ha		
	Chewang lodge		0.51 Ha		
	Bhaky Chourichokh		0.25 Ha		
	Himchuli Lodge		0.51 Ha		
Sandakphu	Trekker's Hut, GTA(A,B,C)	India	0.25 Ha	10	34 km
	Hotel Sherpa Chalet (Indian + Nepal)		1.5 Ha		
	Hotel Sunrise (Nepal		0.11 Ha		
	Hotel Namo Buddha(India)		0.11 Ha		
Phalut	Trekker's Hut, GTA	India	0.25 Ha	No	NA
Srikhola	Trekker's Hut, GTA	India	1 Ha	1	50 km
	Hotel Shovraj		1 Ha		
	Goparma Lodge		1 Ha		
Gurdum	Himalayan Sherpa Lodge	India	1 Ha	No	NA
	Lakpa Dorjee Sherpa's Home		1 Ha		
Dhotrey	Sherpa Lodge	India	0.3 Ha	1	17 km
Moley	GTA Lodge	India	0.25 Ha		
Gorkhey	Shanti Lodge	India	1 Ha	No	NA
	Eden Lodge		1 Ha		

Figure 3: Hotels At Singalila National Park.

- Total Area occupied by Hotels and Home-stays in Nepal = 8.28 Ha = 82800 Sq.m.
- Total Area occupied by Hotels and Home-stays in India = 10.58 Ha = 105800 Sq.m.

Total Explorable Area

Total explorable area considering roads, trekking routes and hotels with additional neighbouring areas excluding Nepal = 1,123,300 sq.m. which is 1.43 percent of total park area (78.6 sq.km) and including Nepal = 1,206,100 sq.m which is 1.54 percent of total park area (78.6 sq.km).

Pollution Due to Increase in Visitors and Vehicles

Pollution caused by increasing number of visitors and vehicles into the park results in environmental degradation. It results in bio-diversity loss affecting to life-cycle of migratory birds and posing threat to species presented like red panda, barking deer etc. The most noticeable impact on pollution comes from the sharp rise in number of tourists and vehicles. The arrival pattern of tourists and vehicles from 2014-2021 have been presented graphically in fig 5. The pattern shows that a sharp increase of visitors and vehicles into the national park from 2018 has started. We will use the proposed formula (5) here to calculate the impact as per the data in fig 4.

$$Cf_{\text{(for visitors)}} = \frac{1}{7} \left[\frac{1170}{10690} + \frac{1087}{11860} + \frac{-2226}{12947} + \frac{10452}{10721} + \frac{7251}{21173} + \frac{1180}{28424} + \frac{-1334}{29604} \right] \times 100 = 19.20$$
 Similarly, $Cf_{\text{(for vehicles)}} = 41.04$.

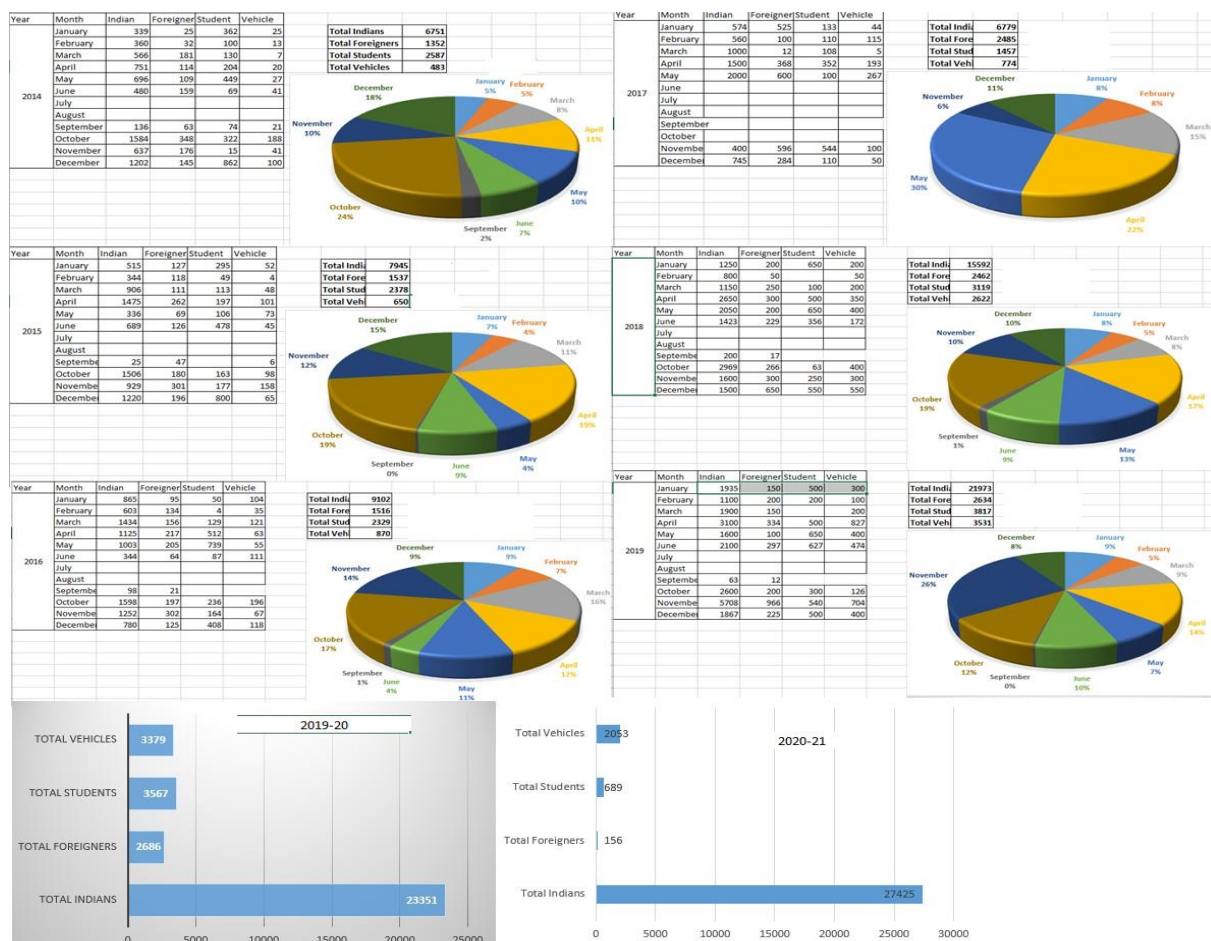


Figure 4: Tourists and Vehicles Data (Tourists' Arrival Statistics Vehicle-Count from 2014 to 2021).

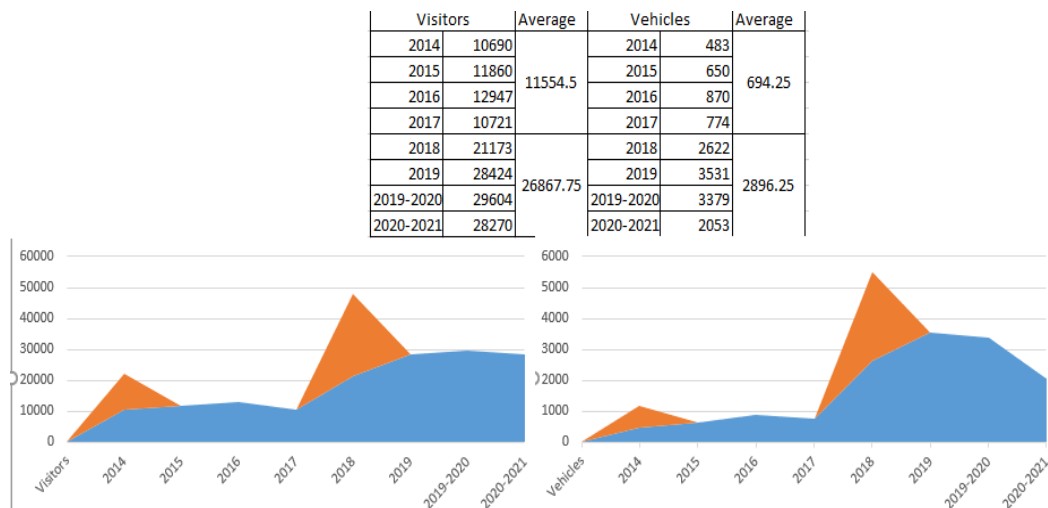


Figure 5: Pattern of Tourists and Vehicles Inflow.

PCC for the Territories Suitable for Extensive Tourism

Explorable area of Singalila National Park excluding Nepal = 1,123,300 sq.m. (TOTAL EXPLORABLE AREA).

Explorable area of Singalila National Park Including Nepal = 1,206,100 sq.m. (TOTAL EXPLORABLE AREA).

$$R_f = \frac{\text{period of location availability}}{\text{average visit time}} = 0.36 \times \left[0.67 \times \frac{12}{4 \times 12} + 0.33 \times \frac{12}{12} \right] + 0.64 \times \left[0.36 \times \frac{12}{4 \times 12} + 0.64 \times \frac{12}{12} \right] =$$

0.646, Since the park available for visit in day time is approximately 12 hours a day and considering a trekker spends generally 4 days in the park and a tourist by vehicle spends a day and returns. We see from data of the tourists and vehicles, in 2014-2017, average number of vehicles in a year into the park is 694.25. Now if we take, 6 tourists are going to the park by a car, such type of total tourists count goes to 4,166 in the year. Rest tourists are trekkers. Such number in average in a year during 2014-2017 becomes 7389. From 2018 onwards, tourists by car and trekkers count becomes 17,378 and 9490 respectively. So, the ratio between number of tourists by vehicles and number of trekkers, as data reveals, is approximately 0.56 i.e., 1:2 nearly from 2014- 2017 and from 2018 onwards it becomes 1.83, i.e., 9:5 nearly. Giving the most weight of the data to the recent year 2020-2021 = 7, 2019-2020 = 6, 2018 = 5, 2017 = 4, 2016 = 3, 2015 = 2, 2014 = 1, the weight ratio of 2014-2017 data and 2018-2021 data becomes: 10:18, i.e., 5:9.

$$\frac{v}{a} = \frac{1}{4^2} = \frac{1}{16}.$$

Thus, Pcc calculated for extensive tourism is as follows:

- Pcc (excluding Nepal) = $1,123,300 \times 0.646 \times \frac{1}{16} = 45,353$.
- Pcc(including Nepal) = $1,206,100 \times 0.646 \times \frac{1}{16} = 48,696$.

RCC for the Territories Suitable for Extensive Tourism

As per the assumption in 3.1 total rain/snow/no or low-tourist days are around 30 days i.e., 360hours, $[30 \times 12 = 360]$, of limitation on visit to the national park posed by the prevailing weather. Again, the park remains closed to visitors/tourists from 16th June to 15th September every year. So, total hours with climatic limitations and with no-entry to the park is

$$\frac{360+1080}{4380-1080} \times 100 = 43.64. \text{ Bad weather condition results in low or no tourists into the park and there by enhances the}$$

environmental parameters and increases the carrying capacity; whereas increase in number of visitors and vehicles degrades those parameters and decreases the carrying capacity; hence impact of increase in number of visitors and vehicles has inverse relation with carrying capacity and that of the bad weather has direct relationship. A sharp increase of visitors into the national park from 2018 has impacted its environmental resources. As shown in the section POLLUTION DUE TO INCREASE IN VISITORS AND VEHICLES, $Cf_{\text{(for visitors)}} = 19.20$ and, $Cf_{\text{(for vehicles)}} = 41.04$. So, using the formula (3), $RCC(\text{excluding Nepal}) = 45,353 \times 0.5636 \times 0.808 \times 0.5896 = 12,177$ and $RCC(\text{including Nepal}) = 48,696 \times 0.5636 \times 0.808 \times 0.5896 = 13,074$.

ECC of the Park

In the last four years 2018-2021, number of total tourists to the park is 26868. For better management, it is considered that a guide should handle a team of 6-7 tourists. So total number of guides that should ideally be required is 3,838-4,478. But registered guide available for the tourists' guidance is 38 (Figure. 6). Additionally, considering land rovers' drivers as guide, the number goes up to $38 + 75 = 113$. Here is a huge management gap. So, till now, we have $\frac{113}{3,838} = 3$ percent capacity in respect of guidance to the tourists.

Ambulance is one of the major emergency facilities. It needs to be well maintained. For the park, nearest three ambulances are available at Sukhiapokhri which is 7 km from Maneybhanjan. Additionally, inside the park some local land rovers are available. Such local vehicles are 35 (how many Vehicles are available at which location is given in fig. 3). Giving leastweight to the local vehicles nearest to Sukhiapokhri and increasing the weight of the location with the increase of the distance from Sukhia (since, a patient needs emergency attendance more quickly and readily as distance increases, so, we assign more weight to a point/location as the distance increases from Sukhia). So, the weighted average of the ambulances/local vehicles (at Lamaydhura, Tonglu, Gairibas, Kalipokhri, Sandakphu): $2 \times 0.100632547 + 9 \times 0.111558367 + 2 \times 0.161012076 + 0 \times 0.17826337 + 9 \times 0.212765957 + 10 \times 0.235767683 = 6$. the weighted average of the ambulances/local vehicles (at Srikhola and Dhotrey): $1 \times 0.413043478 + 1 \times 0.586956522 = 1$. So, we can consider any of the seven local vehicles and three ambulances of Sukhia can be made available for emergency purpose. So, total existing ambulances/local vehicles for emergency purpose is 10. Now as per WHO guideline, Ambulance should reach the emergency patient within 15-20 minutes. In Singalila, there are 14-15 points like Tumling, Gairibas, Sandakaphu etc. are available. Average distance between two points is around 6-7 km. The ambulances required in total 103 km motorable road in the park to attend each point and in-between locations within 20 minutes, $\frac{103}{6} = 17$, (considering an ambulance takes 20 minutes average to go 6 km). So, the existing capacity in this ground is $\frac{10}{17} = 0.59$.

Land rovers available to take the tourists are 75 in numbers (Fig. 7). Number of vehicle entry in 2020-2021 is 2896.25, i.e., considering only these 75 vehicles goes to the park, each vehicle trips $2896.25 / 75 = 38$ times in nine months when the park becomes open. That means per month a car goes 4 times. It means a car travels all the 4 weeks a month, considering, 4 days a trip and 2 days for rest. It is better for the car health and healthy trip to have at least a week rest, i.e., 3 trips a month. So, in this trip management respect, we have multiplying factor 0.75.

$$MC = \frac{(0.75 + 0.59 + 0.03) \times 100}{3} = 0.46.$$

Considering all these management constraints, Ecc (excluding Nepal) of the Singalila National Park using the equation (7) = $12,177 \times 0.46 = 5601$ and Ecc(Including Nepal) = $13,074 \times 0.46 = 6,014$.

Sl. No.	Name	Sl. No.	Name	Sl. No.	Car number	Sl. No.	Car number	Sl. No.	Car number	Sl. No.	Car number
1	Dawa Tamang	20	Taksik Bhutia	39	WB 770219	40	WB 771614	58	WB 772794		
2	Shyam Bahadur Tamang	21	Passang Tshering Bhutia	41	WB 770015	42	WB 76A4817	59	WMX 0067		
3	Sanga Bhutia	22	Arpan Gurung	43	WB 019294	44	WB 770262	60	WB 76 A7884		
4	Prakash Rai	23	Amar Gurung	45	WB 201711	46	WB 76 A5864	61	WB 77 3206		
5	Buddha Tamang	24	Bijay Rai	47	WB 761464	48	WB 76 A6337	62	WB 77 3978		
6	Gautam Tamang	25	Namper Tshering Lepcha	49	WB 771103	50	WB 76 A1496	63	WB 783418		
7	Birdhan Tamang	26	La Tshering Lepcha	51	WB 779154	52	WB 77412K	64	WB 775377		
8	Santay Tamang	27	Lakpa Lepcha	53	WB 763721	54	WB 772097	65	WB 776399		
9	Mingma Tamang	28	Yojesh Rai	55	WB 772917	56	WB 76 A9922	66	WB 781752		
10	Nagen Tamang	29	Dipesh Tamang	57	WB 764233	58	WB 771158	67	WB 790531		
11	Gyurmey Tenzin	30	Sanjip Tamang	59	WB 768569	60	WB 76 A4583	68	WB 783556		
12	Bikram Chettri	31	Bikash Tamang	61	WB 773525	62	WB 770173	69	WB 760212		
13	Phupu Tshering Bhutia	32	Suresh Chettri	63	WB 76 A5336	64	WB 76 A5891	70	WB 761492		
14	Tshering Bhutia	33	Gopal Rai	65	WB 767319	66	WB 771105	71	WB 76 A1355		
15	Tenzi Tamang	34	Sonam Tshering Sherpa	67	WB 774969	68	WB 771743	72	WB 76 A1355		
16	Rudra Chettri	35	Raju Chettri	69	WB 772917	70	WB 761546	73	WB 76 A551		
17	Kumar Tamang	36	Ram Limbu	71	WB 764233	72	WB 771158	74	WB 776100		
18	Nima Sherpa	37	Pemba Sherpa	73	WB 768569	74	WB 76 A4583	75	WB 778763		
19	Zamling	38	Abhishek Tamang	75	WB 773525						

Figure 6: Registered Guides (2021 Data).
Figure 7: Land Rovers / Vehicles for Tourists.

RESULTS & DISCUSSIONS

The inflow of vehicles and tourists into the national park stood around 13,000 till the year 2017 whereas the number increased to maximum 33,000 with an average of 30,000 from 2018 onwards. If this trend continues, the effective carrying capacity will be decreased further from 5601 (which is obtained with the data till 2021). It is a serious matter of concern for the sustainability of the eco-system of the national park and red panda habitat. To protect the bio-diversity of the national park, the entry of tourists and vehicles should be restricted to check the pollution and maintain a balanced effective carrying capacity.

CONCLUSIONS

Restricted by visitors' inflow, vehicles' entry, the vastness of the area, space ideally to be available to each visitor and specific visiting time in a year-round supported by the existing infrastructure and management, the effective carrying capacity, as calculated, becomes 5,601 (excluding Nepal infrastructure) and 6,014 (including Nepal infrastructure), exceeding which results in biodiversity degradation.

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